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Thermohydraulic analyses on CEA concept of TF and CS coils for EU-DEMO

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In the framework of the European fusion program for energy, EUROfusion funds the studies for the future fusion power demonstrator reactor DEMO. CEA is involved on the conceptual design of the superconducting conductors for the Toroidal Field (TF) and Central Solenoid (CS) magnets. The CEA design proposal corresponds to Wind and React Nb3Sn pancake-wound coils using Cable-In-Conduit Conductors (CICC) cooled at about 4.5 K by forced flow of supercritical helium. The present paper presents the latest thermohydraulic analyses performed on both TF and CS conductors. Two TF conductor designs have been analyzed, with nominal current of 111 kA and 88 kA respectively. The analyses were performed in normal (burn) and off-normal (quench) conditions. Burn simulations focused on the central and lateral pancakes, heat load corresponding to neutron heating. The central pancake is the most critical one regarding the magnetic field while the lateral one receives a more important heat load from the casings. The influence of case cooling on temperature margin (DTma) was analyzed by means of a dedicated 2D Cast3M model. The DTma sensitivity to driving parameters such as conductor pressure drop, friction factor and heat exchange correlations was analyzed. The impact of inter-turn thermal coupling on temperature margin was also assessed. In addition, the simulation of a sequence of several burn/dwell is presented. Quench studies on TF conductors have been explored in several scenarios corresponding to events that can lead to a quench: heat deposition due to a plasma disruption, cryogenic malfunction and fusion power excursion. Regarding the CS conductor, burn analyses are exposed on the latest design featuring a nominal current of 53.7 kA, focusing on the impact of AC losses and of dwell duration.

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